

Disease Resistant Lettuce Strains

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IN THE fall of 1922, the writer was sent to California by the United States Department of Agriculture for the purpose of investigating lettuce mildew and a new disease of lettuce, since named brown blight, in Imperial Valley. This article is a progress report on the investigation and control of these diseases to date.

Brown blight never shows until the lettuce seedlings have developed 5 to 10 leaves each, usually after the crop has been thinned. Reaching the point of development plants are attacked in all stages of growth. When attacked while small, the plants take on a somewhat mottled yellowish sickly color, and make only a much stunted rosette-like growth with no inclination to form heads. Plants attacked after heading is well started show dead brown irregular streaks and blotches in the outer leaves of the head, in addition to a yellowish discoloration of the whole plant. The leaves of diseased plants gradually dry up and turn brown, beginning at the bottom.

In lettuce fields there may be only an occasional diseased plant, or there may be irregular areas from a few feet to several rods in diameter where practically all plants are diseased. The more or less isolated areas, where the plants are stunted and dying, are very notice-

IN APPRECIATION

Dr. Ivan S. Jagger has given outstanding service to the vegetable industry of the West in his development of blight resistant strains of lettuce. It is largely to him that the lettuce industry owes its remarkable growth in recent years, for his introductions have not only made possible the maintenance of lettuce production in certain areas, but have, through higher yields, cut production costs materially and improved quality. The Western Growers Protective Association takes this opportunity to express their appreciation to the United States Department of Agriculture in making available such an outstanding scientist for this work, and to acknowledge the great service which Dr. Jagger has rendered to the Western lettuce industry. We also express the wish that he will be continued in this work and that the Department will cooperate in placing sufficient funds for the research now being carried forward with so much success.—C. B. Moore.

able in moderately infested fields. In severe cases 50 to 95 per cent of the plants over whole fields may be affected. Most diseased plants never make anything suggestive of marketable heads, but occasional heads, which show early stages of the brown streaking and blotching in the outer leaves, get into the markets.

Brown blight is a soil borne disease which may occasionally cause some injury in soil where lettuce is being grown for the first time. However, it usually causes trouble only where a second, third or later crop of lettuce is grown on the same soil. Where a lettuce crop shows any appreciable amount of disease, another crop on the same soil is certain to show greatly increased disease.

Fine, silty water deposited types of soil seem to develop brown blight much more rapidly from year to year than loamy types of soil. In many fields of silt type soils in Imperial Valley, brown blight has made it impossible to grow more than one or two crops of susceptible lettuce, while many fields of loamy type soils in the Salinas-Watsonville, California, and the Salt River Valley, Arizona, sections have produced five to ten good crops.

In spite of the fact that brown blight

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BLIGHT RESISTANCE PROVED IN FIELD TEST

In this test plot, the center bed, planted to the best commercial New York lettuce, was 100 per cent brown blighted. On the left is a planting of Imperial No. 2, and on the right, Imperial No. 3. There was practically no blight in the Imperial strains.

Under such conditions about this strain is the high percentage

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seems to attack only lettuce, rotation of crops has little or no value in combating it. Numerous cases have been observed, where growing alfalfa or similar crops on lettuce-sick soil for three to five years, has given no apparent benefit in reducing the disease in the soil.

Brown blight has so far caused trouble principally in Imperial Valley, where it is now difficult to find soil which will grow satisfactory crops of the susceptible New York variety. It is on the increase and is beginning to cause losses in the Salinas-Watsonville and Santa Maria, California, sections and in the Yuma, Arizona, section. It occurs to a less extent in the Salt River Valley of Arizona. So far as known at present, the disease is confined to Arizona and California.

Search for Resistant Strains

IN HOPES of finding resistance to brown blight, about 100 varieties of lettuce from many parts of the world were grown in severely diseased soil in Imperial Valley in 1923. Two varieties, Big Boston and White Chavigne, were entirely immune and made normal growth on severely diseased soil in 1923 and later years. These varieties

are, however, of no commercial use in California and Arizona. Crosses had been made in 1922 between White Chavigne and the New York variety, grown almost exclusively in the Pacific Coast and Rocky Mountain lettuce sections. Breeding and selecting of these crosses are now, after seven years work and five to ten generations of lettuce, beginning to give strains, which combine the resistance of the White Chavigne parent with the type of the New York parent. None of these strains are in commercial use.

The development of resistant strains from crosses or hybrids was known to be a slow and laborious procedure. Consequently the generally much shorter process was undertaken—that of finding in fields of the standard variety resistant single plants from which to breed up resistant strains or varieties.

In 1923, many diseased fields of New York lettuce were searched over in the hopes of finding such plants, but without success. In 1924, however, a single badly diseased field of New York was found in which there was occasional normal healthy plants, entirely surrounded by diseased plants, and giving every indication of withstanding the disease which was destroying neighboring plants.

Many of these apparently resistant

plants were "sports" and "off types," indicating that their resistance may have originated from natural chance crosses between New York and some resistant variety several generations previous. Some apparently resistant plants were, however, making good marketable heads and were at least very similar to New York. About 125 of these most promising plants were selected, and seed grown and harvested separately from each plant. One or more breeding plants, consisting of 25 feet of double row each, were planted with seed from each of the 125 selected plants on badly diseased soil in 1925.

The trials in 1925 were very encouraging. As was expected, some of the trial plants showed no healthy plants, and many showed only part healthy plants, but several plats showed practically no diseased plants and made good marketable heads of the New York type on very severely diseased soil.

The commercial value of new strains, however, can not be finally judged from small 25-foot breeding plats. As much seed as possible of the three most promising disease free strains was grown during the summer of 1925 for larger scale trials in 1926. In 1926, these three strains were planted in Imperial Valley in several larger trial plats

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Cantaloupes.....					1,717	9,595	3,667	1,278	363	110	9		16,739
Carrots.....												723	6,419
Califlower.....												1,099	7,224
Celery.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,410	9,417
Cucumbers.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	63
Lettuce.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,932	35,673
Misc. Melons.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10,122
Mixed Vegetables...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	748	5,089
Onions.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51	4,298
Peas, Green.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	249	2,203
Peppers.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	130
Potatoes.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	603	7,721
Spinach.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	437
Sweet Potatoes.....	67	28	4	1	.....	.....	.....	19	143	236	233	64	795
Tomatoes.....	.....	.....	.....	.....	37	204	224	102	736	2,046	831	59	4,239
Turnips.....	14	9	9	3	1	.....	.....	.....	.....	.....	.....	.....	36
Watermelons.....	.....	.....	.....	.....	23	2,032	2,980	1,119	183	21	.....	.....	6,358
Total.....	9,492	8,654	7,771	5,403	11,013	19,131	15,006	8,802	7,593	9,663	8,207	7,980	118,715
Grand Total....	11,242	8,812	8,232	9,379	11,066	19,569	19,884	9,114	7,593	9,664	8,217	9,788	132,580

*From Bureau of Agricultural Economics, U. S. D. A. Subject to Revision.

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under the names Imperial No. 1, Imperial No. 2, and Imperial No. 3. Imperial No. 1 proved to be of very doubtful value and was discarded. Imperial No. 2 and Imperial No. 3 gave good commercial crops, practically free from brown blight on severely diseased soil. Stock seed of Imperial No. 2 and Imperial No. 3 was placed in the hands of seed growers in 1926, and these two strains have been on sale by seedsmen since the fall of that year.

Further selecting and breeding of the 125 selections made in 1924, finally gave another promising brown blight resistant strain. This was distributed in 1928 under the name Imperial No. 6.

Selection for "Double Resistant"

LETTUCE mildew, caused by the fungus *Bremia lactucae*, attacks only the loose exposed leaves. Yellow areas appear in the leaves covered, usually only on the under surfaces, with white mildew. Lettuce may be retarded at any stage of growth by mildew attacking and eventually killing some of the older leaves, but affected plants continue to grow and invariably make more or less normal salable heads. Harvested

lettuce heads sometimes show mildew on the outer exposed leaves, which may cause little loss when marketed locally. Such lettuce shipped to distant markets under refrigeration is likely to arrive with many of the mildewed leaves in a soft decayed condition. Mildew causes trouble principally during periods of heavy dews and more or less rain. There is usually some lettuce mildew in the coastal lettuce sections of California every season. Under drier climatic conditions in Imperial Valley, it occurs only during an occasional season when there is an unusual amount of rain and dew.

In 1922, crosses were made between the New York variety of lettuce, which is very susceptible to mildew, and a cos or romaine variety, obtained from France, which is very resistant. Considerable progress had been made in breeding up mildew resistant New York types from this cross by 1925, when the brown blight-resistant mildew-susceptible Imperial No. 2 and Imperial No. 3 strains were crossed with the more promising of these mildew resistant selections. Continued selection from these double crosses has finally, in 1930, given strains of the New York type which are resistant to both brown blight and mildew, or "double-resistant." The two most promising double resistant strains

have been named Imperial C and Imperial F.

Stock seed of these two strains has just been placed in the hands of some of the leading lettuce seed growers with the understanding that their resulting 1930 seed crops will be marketed through regular seed trade channels in small lots at reasonable retail prices. It is hoped that this arrangement will result in the new strains being available to a large number of lettuce growers in sufficient amounts for thorough field trial in 1931. So far as tested, Imperial C and Imperial F have been highly resistant to both brown blight and mildew, and have under favorable conditions made good commercial crops. It should, however, be distinctly understood that these strains have been tested only one year and only in $\frac{1}{4}$ acre plats, and that several years are necessary to fully determine the commercial possibilities of new strains.

So that the names of the new resistant strains may not be confused, all disease resistant strains have been given the name Imperial. Strains resistant to brown blight only are designated by Imperial and a number, and double resistant strains by Imperial and a letter. Thus Imperial No. 2, Imperial No. 3, and Imperial No. 6 are resistant to

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brown blight, but are susceptible to mildew, while Imperial C and Imperial F are resistant to both brown blight and mildew. The same system of naming will be applied to any later strains which may be developed.

All the disease resistant strains are of the same general type as the New York variety, and are marketed as New York or "Iceberg" lettuce. While the resistant strains show only minor differences in mature heads, they show marked differences from New York and from each other in responses to cultural and climatic conditions. All Imperial strains have, so far, made entirely satisfactory crops on severely brown blight infested soil. Imperial C and Imperial F have, so far as tested, shown little or no mildew under conditions where New York has been heavily attacked.

New Strains Described

Imperial No. 2 (Introduced 1926, resistant to brown blight only) Mature heads are similar to New York but considerably larger and sometimes coarser in texture. This strain has made very good crops in Imperial Valley during midwinter when the nights are cold and often frosty. Under such conditions

it makes larger and higher grade crops than New York. Under warmer conditions, where there are no frosty nights, Imperial No. 2 tends to head poorly and to show tip burn and slime, being inferior to New York in both respects. It usually requires 5 to 10 days longer to mature than New York.

Imperial No. 6 (Introduced 1928, resistant to brown blight only). Mature heads are much larger than New York and some larger than Imperial No. 2. They are usually coarser in texture and more "ribby" than New York. This strain has made some of the heaviest crops ever grown in Imperial Valley, but in general has been unsatisfactory in other sections. It requires even more than Imperial No. 2. In Imperial Valley during the warm winter of 1930 it headed very poorly while Imperial No. 2 headed very satisfactorily. Imperial No. 3 usually requires 10 days longer to mature than New York.

Imperial No. 6 Introduced 1928, resistant to brown blight only). This strain is newer than Imperial No. 2 and Imperial No. 3. At present, it promises to be superior to both Imperial No. 2 and Imperial No. 3 for many uses. The mature heads are larger than New York and of good quality, but smaller than No. 2 or No. 3. The outstanding thing about this strain is the high percentage

of very hard marketable heads. It will undoubtedly head well under warmer conditions than the two preceding. There is doubt about its standing as much warm weather as New York, since it seems to be somewhat more susceptible to tip burn. An objectionable feature of this strain is its tendency to produce "side-shoots" in the axils of the loose outer leaves below the head.

All the numbered Imperial strains are more resistant to heavy frosts than New York, and Imperial No. 6 is probably the most resistant of all. It requires 5 to 15 days longer to mature than New York.

Imperial C (Introduced 1930, resistant to both brown blight and mildew). So far as tested this strain seems to be more or less intermediate between Imperial No. 2 and Imperial No. 6. It promises to make very satisfactory main crop lettuce in Imperial Valley, but should be planted only on a trial basis under warmer conditions. It requires about the same time to mature as Imperial No. 6.

Imperial F (Introduced 1930, resistant to both brown blight and mildew). Like Imperial C, this strain has been so little tested that no positive statements can be made regarding it. It seems to be very similar to New York

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